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Literature-Review Screening Techniques for the Evaluation of Land Treatment of Industrial Wastes

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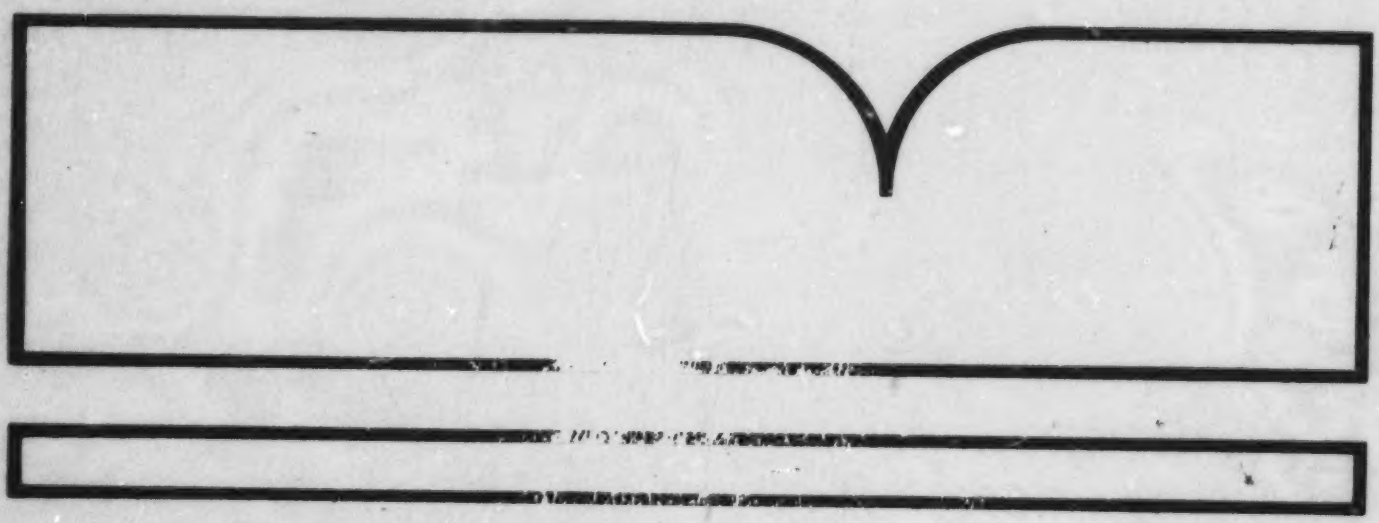

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16. ABSTRACT

This report describes a four-stage screening process for identifying waste streams that are listed as hazardous in the Federal Register (Vol. 45, pp. 74890-74892, November 12, 1980) and that are promising candidates for land treatment research.

The first stage used an inorganic screen for waste streams listed as hazardous solely on the basis of heavy metal content. The basis for screening was the assimilative capacity of a soil pH of 65, and cation exchange capacity of 15. Calculations were made of the land area required to assimilate the quantity of waste generated by a single plant of average size over a period of 10 years. If the calculated area was no greater than 40 ha (100 acres), the waste stream was considered to be high priority for research.

Stage 2 used an organic screen for waste streams listed as hazardous solely on the basis of organic chemical content. The screening was based primarily on the potential for degradation of hazardous components in the soil.

Stage 3 applied an inorganic and an organic screen in sequence to the two waste streams listed as hazardous because they contained both heavy metals and organic chemicals.

Stage 4 involved waste streams listed as hazardous on the basis of cyanide content. Available data were insufficient to identify promising research candidates. Therefore, cyandies can be degraded in a suitable designed land treatment facility. The land-limiting constituent of these waste streams is more likely to be heavy metals than cyanides.

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LITERATURE-REVIEW SCREENING TECHNIQUES FOR THE EVALUATION OF LAND TREATMENT OF INDUSTRIAL WASTES

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimonies to the deterioration of our natural environment. The complexity of that environment and the interplay of its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution; it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, to preserve and treat public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research and provides a most vital communications link between the researcher and the user community.

Land treatment is managed utilization of the natural assimilative capacity of soils to dispose of wastes without precluding any future potential societal usage of the land. Land treatment has been used for the management of petroleum refining industry wastes for over 25 years, and has potential for the management of other industrial wastes.

Francis T. Mayo, Director
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ABSTRACT

This report describes a proposed four-stage literature-review screening process for identifying waste streams that are listed as hazardous in the Federal Register (Vol. 45, pp. 74890-74892, Nov. 12, 1980). The method will allow the evaluation of promising candidate waste streams for land treatment.

The first stage is an inorganic screen for waste streams listed as hazardous solely on the basis of heavy metal content. The basis of screening was the assimilative capacity of a soil pH of 6.5 and cation exchange capacity of 15. Calculations are made of the land area required to assimilate the quanity of waste generated by a single plant of average size over a period of 10 years. If the calculated area was no greater than 40 ha (100 acres), the waste stream was considered to be high priority for research. Only the listed waste streams from the petroleum refining industry ranked high in priority on the basis of this screen. The petroleum refining industry wastes are listed as hazardous because of high chromium and lead concentrations. Of course, these streams also contain petro-chemicals that are degraded in a land treatment system.

Stage 2 is an organic screen for waste streams listed as hazardous solely on the basis of organic chemical content. The screening is based primarily on the potential for degradation of hazardous components in the soil. A number of industrial wastes were identified as promising candidates for land treatment.

Stage 3 is an inorganic and an organic screen in sequence to the two waste streams listed as hazardous because they contained both heavy metals and organic chemicals. Ammonia still lime sludge is a promising candidate for land treatment research.

Stage 4 involves waste streams listed as hazardous on the basis of cyanide content. Available data are insufficient to identify promising research candidates. Heavy metals are more likely to be the land-limiting constituents than cyanides since the latter can be degraded in a suitably designed land treatment facility. Information on heavy metal content is not available.

This report was submitted in fulfillment of Contract No. 68-03-2930 by Arthur D. Little, Inc. under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period March 18, 1980, to February 24, 1981, and work was completed as of April 14, 1982.

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SECTION 1

INTRODUCTION

BACKGROUND

Land-treated hazardous waste constituents are detoxified or immobilized through the controlled use of physical, chemical and biological processes that occur naturally in the upper 6 to 8 inches of soil systems. Examples of the types of treatment that can occur in the well aerated soil systems include[1]:

- Aerobic microbial decomposition of organic chemical components of the waste;
- Chemical oxidation and/or hydrolysis;
- Ion exchange;
- Precipitation; and
- Neutralization.

Land treatment has been used for oily wastes from the petroleum refining industry for more than 25 years. None of these land treatment facilities, which are located in many different parts of the country, are known to have resulted in damage to human health or the environment. Furthermore, extensive monitoring of field sites has demonstrated that certain types of oily wastes are transformed in an aerobic soil environment to a less hazardous or nonhazardous composition.

Land treatment is not used extensively for hazardous wastes other than petroleum refining wastes, but this method may be feasible for other types of wastes.[1] If feasibility can be demonstrated, land treatment has two potential advantages over alternative treatment/disposal methods. First, land treatment is considerably less expensive than incineration, secure chemical landfill, and other types of physical, chemical, and biological treatment processes. Second, if a land treatment site is well controlled, subsequent beneficial uses of the land are not precluded.

Federal regulations governing the use of land treatment for the management of a hazardous waste require a demonstration of the effectiveness of the method.[1] In particular, it must be shown that the waste can be made less hazardous or nonhazardous by biological degradation or chemical reactions

occurring in or on the soil.

The U. S. Environmental Protection Agency (EPA) has issued a Technical Resource Document[2] that describes a systematic methodology for evaluating the technical feasibility of land treatment for any particular hazardous waste. In general, a three-step process is involved:

1. Detailed analysis of the waste and review of available information on the biological and chemical action of natural soil treatment processes on each of the waste constituents. This step can provide a preliminary indication of whether or not land treatment is sufficiently promising to warrant further investigation. In general, this step will also identify gaps in the available data base that need to be filled through subsequent laboratory or field tests.

2. Laboratory and greenhouse studies under simulated field conditions to obtain basic data on degradability, sorption, mobility, volatilization, and toxicity. These data should be suitable for developing a preliminary land treatment facility design and operating plan.

3. Pilot field studies to verify the technical and economic feasibility and the environmental acceptability of the preliminary design and operating plan formulated in Step 2.

Each step in the above process requires an increased commitment of resources.

OBJECTIVES

The purpose of this report is to present a screening process for identifying waste streams that are listed as hazardous in the Federal Register (Vol. 45, pp. 74890-74892, November 12, 1980) and that are promising candidates for land treatment research. The specific objectives of the contract were:

- To develop a literature-review screening technique for the evaluation of land treatment of industrial wastes.

- To identify listed hazardous waste streams potentially amenable to land treatment.

- To make use of readily available data to rank listed waste streams in order of potential land treatment feasibility.

SECTION 2

METHODOLOGY FOR ASSESSING THE POTENTIAL OF LAND TREATMENT FOR HAZARDOUS WASTE STREAMS

ASSIMILATION CRITERION

Basically, a listed hazardous waste is potentially amenable to land treatment if the hazardous components can be assimilated within the upper 15 to 20 cm (1 to 8 in.) of the soil into which the waste is incorporated. The hazardous components of a waste are said to be assimilated if:

- the application area can be used for any other purpose at the end of the post-closure period; and
- migration from the application area of waste-related chemicals (i.e., components of the waste and their transformation products) does not adversely affect human health or the environment at any time during or after the period of application.

The potential for assimilation is the major attraction of land treatment as a hazardous waste management option. If land treatment proves to be appropriate, it can be applied without an irreversible or irretrievable commitment of land resources.

Very few data are available to assess the assimilative capacity of a particular site for a particular waste stream. In general, such an assessment must be done on a waste-specific site-specific basis, as described in the EPA Technical Resource Document on land treatment.[2]

LAND TREATMENT SCENARIO

For the screening purposes of the present report, a land treatment scenario was developed, and listed waste streams were ranked on the basis of known hazardous components. The elements of the land treatment scenario are as follows:

- The annual rate of application of a listed waste stream is assumed to be equal to the average rate of generation of that waste stream from a typical manufacturing plant. In other words, it is assumed that the land treatment site is dedicated to waste of a particular type generated by a single plant.
- The available application area is assumed to be no greater than 40 ha. (100 acres), which is the size of a relatively large landfill.

The assumption is that no larger area would be dedicated to an individual waste stream from a single plant. In practice the median size of existing facilities is only 13.5 acres, and there are facilities that are several hundred acres in size.[10]

- The depth of incorporation of wastes is assumed to be 15 cm (6 in.), the technical agricultural zone or plow layer.[3]

- The site is assumed to be used for land treatment of wastes for a period of 10 years.

- The soil pH is assumed to be maintained between 6 and 7.5 These conditions are generally not difficult to maintain, and they strongly affect the accumulation limits of heavy metals in the soil.

Two screens were developed, an inorganic screen and an organic screen. The inorganic screen has been applied to wastes that are listed because of hazardous heavy metal components. The organic screen has been applied to wastes that are listed because of hazardous organic chemical components. Both screens were applied to wastes that are listed as hazardous because of both heavy metal and organic chemical components.

INORGANIC SCREENING METHODOLOGY

The inorganic screen is quite straightforward and is based on the land-limiting constituent concept introduced by Overcash.[3] The first step is to calculate the quantity of each heavy metal generated in the waste stream of an average plant over a 10-year period. Data for this calculation were obtained primarily from the EPA background document supporting the listing of the waste stream. The background documents typically contain the following relevant information for each waste stream (units in parentheses):

1. Annual rate of generation for each waste stream by all U.S. plants (kg/yr).

2. Number of manufacturing plants generating each waste stream.

3. Average rate of waste stream generation per manufacturing plant (kg/yr per plant)(i.e., the quotient of items 1 and 2).

4. Chemical components of the waste stream.

5. Average concentration of each chemical component in the waste stream.

The second step in the inorganic screen is to determine the area required for assimilation of the heavy metal components of the waste stream. This area is calculated by dividing the output from the first step (quantity of metal [kg] in the waste from a typical plant to be land treated on a given site over a 10-year period) by the allowable cumulative limit (kg/ha) for the metal in question. Allowable cumulative limits have been reported

for a number of metals (Tables 1 and 2). The values are generally reported as a function of the cation exchange capacity (CEC) of the soil (Table 1). As the CEC increases, the allowable cumulative limit for a given metal increases also.

If the calculated area required for assimilation of any heavy metal in the waste stream exceeds 40 ha (100 acres), the waste stream is evaluated as having low priority for further research. If the area is less than 40 ha (100 acres), the waste stream is assigned a high priority for research.

ORGANIC SCREENING METHODOLOGY

The persistence of the individual chemical constituents that make up each waste stream is the most important factor in determining the suitability of the waste stream for land treatment. For screening purposes, the persistence might most conveniently be expressed in terms of the expected half-life for degradation of the chemical in the soil environment. From the half-life it would be possible to calculate the degree of treatment that could be accomplished over a given time increment. For example, a chemical with a half-life of less than 9 months would be more than 99.99% degraded in 10 years. Unfortunately, the data necessary for estimating the half-lives of organic chemicals with respect to chemical and biological degradation in soils are gererally not available. Published studies [4-8] of biodegradation of organic chemicals refer primarily to aqueous culture media and to microbial populations (monocultures of specific organisms, sewage sludge inoculum, etc.) that are not necessarily representative of the soil environment. Furthermore, few studies provide quantitative data on persistence or degradation rates across for the range of organic compounds that are of interest in the hazardous waste context. A review of the literature showed that the biodegradation study conducted by Tabak et al. [8] on a large number of organic priority pollutants provided the most appropriate, internally consistent data base for evaluating the inherent persistence of the specific organic waste components. The Tabak study uses an aqueous medium and a sewage-sludge-derived microbial population rather than a soil or simulated soil situation. Although the absolute rates of degradation reported by Tabak cannot be assumed to apply to a soil environment, the data were thought to provide a useful indication of the relative persistence of a variety of specific organic chemicals.

The Tabak, et al. biodegradability test method was a static culture flack screening procedure [8]. BOD dilution water containing yeast extract at 5 mg/L and the organic chemical of interest at 5 or 10 mg/L was used as the synthetic medium. This solution was inoculated with a microbial population by adding settled domestic wastewater. The culture was statically incubated for 7 days at 25°C. A fresh culture medium containing the same chemical concentration was then inoculated with a few milliliters of the first culture and incubated for another 7 days at 25°C. The percent degradation of the chemical compound was determined by gas chromatography (GC) analysis.

The following steps are involved in the screening process developed for the listed waste streams whose hazardous components are all organic chemicals:

TABLE 1. ALLOWABLE CUMULATIVE LIMITS FOR METALS BASED ON SOIL CEC*

	Soil CEC		
Metal	< 5	5 to 15	> 15
Cd	5	10	20
Cu	125	250	500
Pb	500	1000	2000
Ni	50	100	200
Zn	250	500	1000

TABLE 2. RANGES OF ALLOWABLE CUMULATIVE LIMITS FOR OTHER METALS *,+

Metal	Limit
Mn	500-1000 kg/ha
Hg	8-10 kg/ha at 500 kg/ha/year of N
Sn	2000 kg/ha
Ti	very high
Sb	< 800 kg/ha
Cr	500 kg/ha (ADL estimate based on a similarity to lead)
As	
Light-textured soils	50 kg/ha
Loams and silt loams	100-200 kg/ha
Clays	500-750 kg/ha

*Source: Reference 3.

+Data not available as a function of CEC.

1. A persistence score is assigned to each hazardous component that forms a basis for listing the waste stream. For hazardous components studied by Tabak et al.[8], the persistence score is assigned as follows:

Persistence Score	% Degradation in Tabak Experiment[8]
-4	0 - 10
-2	11 - 30
0	31 - 50
+2	51 - 90
+4	91 - 100

The percent of degradation is that reported by Tabak et al. at the end of the second incubation period. Where different biodegradation rates were reported for 5 and 10 mg/L test concentrations, the lower degradation rate was used for scoring.

Compounds not tested by Tabak et al. are scored by analogy to tested compounds of similar structure, or by use of other literature references as indicated in the table.

2. A persistence score is calculated for each waste stream based on the persistence scores of its hazardous components. The methodology is as follows:

   a. If any hazardous component of the waste stream has a persistence score of -4, the entire waste stream is assigned a persistence score of -4.

   b. If no component of the waste stream has a persistence score of -4, the individual component scores are averaged by one of the two methods that follow:

      i. If data are available on the percent of each compound in the waste stream, a weighted average is taken of the scores for the individual compounds.

      ii. If data are not available on the percent of each compound in the waste stream, a simple (unweighted) average is taken of the scores for each compound.

3. Each waste stream is assigned to one of the following categories, based on the waste stream persistence scores calculated in step 2 above:

- Category I - Least persistent waste stream (waste stream persistence score of +4 or +3)

- Category II - Moderately persistent waste streams (waste stream persistence scores of +2 or +1)

- Category III - Highly persistent waste streams (waste stream persistence scores of < 1)

4. Priorities are set for future research on waste streams within each category based on other available data (e.g., organic loading, hydraulic loading, toxicity of degradation products, reactivity with water) or significant gaps in the data base.

Persistence scores for individual hazardous components of waste streams are given in Table 3.

TABLE 3. PERSISTENCE SCORES OF ORGANIC COMPOUNDS

Compound	Score	Basis	
		Tabak	Analogy (to)
Acetonitrile	+4		C,H,O,N Compounds
Acroleum	+4	5,10:100-100	
Acrylamide	+4		C,H,O,N Compounds
Acrylonitrile	+4	5,10:100-100	
Benzal Chloride	0		Dichloroethane
Benzanthracene	-2	5:16-41	
Benzene		10:0-38	
Benzo fluoranthene	-2		Benzanthracene
Benzopyrene	-2		Benzanthracene
Benzotrichloride	0		1,1,1-Trichloroethane
Benzyl Chloride	+2		Chlorobenzene
Carbondisulfide		5:87-100	
Carbon tetrachloride	+2	10:80-100	
Chlordane	-4	5,10:0-0	
Chloroacetaldehyde	+2		Chlorobenzene
Chlorobenzene	+2	10:30-77	
Chloroethers	+4	5,10:100-100	
Chloroform	+2	5,10:100-100 10:46-70	
Creosote	+4		Phenol
Chrysene	0	1,2,5:26-41	

(Continued)

TABLE 3. (Continued)

Compound	Score	Basis	
		Tabak	Analogy (to)
Cresylic acid	0	5:59-69 10:58-67	
Dichloroethane	0	10:20-35	
O-Dichlorobenzene	+2		Dichloroethane
2,4-Dichlorophenol	+4	5,10:100-100	
2,6-Dichlorophenol	+4		2,4-Dichlorophenol
Dichloropropanol	0		Dichloroethane
Dimethyl phenol			
m-Dinitrobenzene	0		2,4-Dinitrotoluene
4,6-Dinitro-o-cresol			
2,4-Dinitrotoluene	0	5:77-61 10:50-49	
Epichlorohydrin	+4		Chloroethers
Ethylachloride	+2		Chlorobenzene
Ethylene dichloride			
Formaldehyde	+4		C,H,N,O compound
Formic acid	+4	C,H,N,O compound	
Heptachlor	-4	5,10:0-0	
Hexachlorobenzene	-4	5:56-30 10:21-3	
Hexachlorobutadiene	+4	5,10:100-100	
Hexachlorocyclopentadiene	+4	5,10:100-100	
Hexachloroethane	+4	5,10:100-100	

(Continued)

TABLE 3. (CONTINUED)

Compound	Score	Basis	
		Tabak	Analogy (to)
Hydrocyanic acid	+4		C,H,N,O compound
Isobutyl alcohol			
Maleic anhydride	+4		C,H,N,O compound
Methanol			
Methylchloride	+4		Methylene chloride
Methylene chloride	+4	5,10:100-100	
Methyl ethyl ketone			
Methyl isoputyl ketone			
Naphthalene			
Naphthaquinones	+4		C,H,N,O compound
Nitrobenzene	+4	5:100-100 10:87-97	
Nitrophenol (2-)			
Paraldehyde	+4		C,H,O compound
Pentachlorophenol			
Phenol	+4	5,10:96-100	
Phorate	+2		Malthian
Phosphorodithioic acid	+2		Malathion
Phosphorodithioic esters	+2		Malathion
Phosphorothioic esters	+2		Malathion
Picoline	+4	C,H,N,O compound	

(Continued)

TABLE 3. (CONTINUED)

Compound	Score	Basis	
		Tabak	Analogy (to)
Phthalic anhydride	+4		C,H,N,O compound
Pyridine	+4		C,H,N,O compound
Quinones	+4		C,H,N,O compound
Tars (PAHs)			
Tetrachloroethane	-2	5:0-12 10:0-11	
Tetrachloroethylene	0	5:45-54	
Tetrachlorophenol			
Toluene	+4	5,10:100-100	
Toluene diamines	+4		Toluene
Toluene diisocyanates	+4		Toluene
Toxaphene	-4		Heptachlor
Trichloroethanes			
1,1,1	0	5:29-64 10:23-53	
1,1,2	-2	5:6-30 10:0-27	
Trichloroethylene	+2	5:64-73 10:38-56	
2,4,6-Trichlorophenol			
0,0,0-Triethylester, phosphorodithioic acid	+2		Malathion
2,4,6-Trichlorophenol	+4	5,10:100-100	

(Continued)

TABLE 3. (CONTINUED)

Compound	Score	Basis: Tabak	Basis: Analogy (to)
Trichloropropane	0		1,1,1-Trichloroethylene
Vinyl chloride	+2		Chlorobenzene
Vinylidene chloride	+2		Chlorobenzene
Fluoranthene ($C_{16}H_{10}$)	-2		Benzanthrene
Indeno (1,2,3-cd) pyrene	-2		Benzanthrene
Dibenzo (a) anthracene	-2		Benzanthracene
Acenaphthalene $C_{10}H_6(CH)_2$	+4		Naphthalene
p-chloro-m-cresol	+4		Trichlorophenol phenol
Benzene	+4	5:49-100 10:37-95	
Carbon disulfide	+4		MEG list*
Chlorinated fluorocarbons (used trichlorofluoromethane data)	0	5:59-61 10:38-40	
Chrysene	0	5:6-65 10:0-30	
Cresylic acid		(See Phenol)	
Dimethyl phenol	+4	5,10:99-100	
4,6-Dinitro-o-cresol	-4	5:52-58 10:0-5	
Ethylene dichloride (1,2-)	+2	5:54-76 10:43-75	

(Continued)

TABLE 3. (CONTINUED)

Compound	Score	Basis	
		Tabak	Analogy (to)
Isobutyl alcohol	+4		C,H,O compound
Methanol	+4		C,H,O compound
Methyl ethyl ketone	+4		C,H,O compound
Methyl isobutyl ketone	+4	C,H,O compound	
Naphthalene	+4	5,10:100-100	
Nitrophenol (2-)	5,10:100-100		
Pentachlorophenol	-4	5:19-68 10:16-0	
Tars (PAHs)	(See Benzanthracene)		
Tetrachlorophenol	-4		Pentachlorophenol
2,4,6-Trichlorophenol	+4	5,10:100-100	

SECTION 3

RESULTS

WASTE STREAMS FOR WHICH ALL KNOWN HAZARDOUS COMPONENTS ARE HEAVY METAL SPECIES

Waste streams that were listed as hazardous only because of the presence of heavy metal species are shown in Table 4. The results of applying the inorganic screen described in Section 2 to each waste stream are detailed in Table 5. Of the wastes in this group, only those from the petroleum refining industry appear to be high priority candidates for land treatment research (see Table 6). The rankings are based solely on waste stream components cited as the basis for listing.

WASTE STREAMS FOR WHICH ALL KNOWN HAZARDOUS COMPONENTS ARE ORGANIC CHEMICAL SPECIES

Waste streams that were listed as hazardous only because of the presence of organic chemical species are shown in Table 7. The results of applying the organic screen described in Section 2 to each waste stream are detailed in Table 8. Streams assigned a high or moderate priority for research are summarized in Table 6.

WASTE STREAMS CONTAINING HEAVY METALS AND ORGANIC CHEMICAL SPECIES

Only two waste streams are listed because they contain both heavy metal and organic chemical species that are considered hazardous. These streams are described in Table 9. The ammonia still lime sludge from coking operations has been assigned a high priority for research based on the data available.

WASTE STREAMS FOR WHICH THE HAZARDOUS COMPONENT IS CYANIDE

Available data on waste streams listed as hazardous because of cyanide content are summarized in Table 10. The presence of cyanides does not preclude land treatment, since these chemicals are degraded in soils. Cyanides also tend to be highly soluble. Application rates must therefore be balanced so that degradation rates exceed leaching rates. This balance would need to be determined experimentally in the field. Although cyanide is the basis for listing the waste streams in this grouping, the land-limiting constituent is likely to be a heavy metal that is also present. Available data on the heavy metal contents of these waste streams are insufficient to allow ranking.

TABLE 4 WASTE STREAMS LISTED AS HAZARDOUS BECAUSE OF HEAVY METAL COMPONENTS

EPA hazardous waste no.	Waste stream description	Hazardous constituents for which listed
K002	Wastewater treatment sludge from the production of chrome yellow and orange pigments	Hexavalent chromium, lead
K003	Wastewater treatment sludge from the production of molybdate orange pigments	Hexavalent chromium, lead
K004	Wastewater treatment sludge from the production of zinc yellow pigments	Hexavalent chromium
K005	Wastewater treatment sludge from the production of chrome green pigments	Hexavalent chromium, lead
K006	Wastewater treatment sludge from the production of chrome oxide green pigments (anhydrous and hydrated)	Hexavalent chromium
K007	Wastewater treatment sludge from the production of iron blue pigments	Cyanide (complexed), hexavalent chromium
K008	Oven residue from the production of chrome oxide green pigments	Hexavalent chromium
K048	Dissolved air flotation (DAF) float from the petroleum refining industry	Hexavalent chromium, lead
K049	Slop oil emulsion solids from the petroleum refining industry	Hexavalent chromium, lead
K050	Heat exchanger bundle cleaning sludge from the petroleum refining industry	Hexavalent chromium
K051	API separator sludge from the petroleum refining industry	Hexavalent chromium, lead
K052	Tank bottoms (leaded) from the petroleum refining industry	Lead

(Continued)

TABLE 4 (continued)

EPA hazardous waste no.	Waste stream description	Hazardous constituents for which listed
K061	Emission control dust/sludge from the primary production of steel in electric furnaces	Hexavalent chromium lead, cadmium
K062	Spent pickel liquor from steel finishing operations	Hexavalent chromium lead
K064	Acid plant blowdown slurry/sludge resulting from the thickening of blowdown slurry from primary copper production	Lead, cadmium
K065	Surface impoundment solids contained in and dredged from surface impoundments at primary lead smelting facilities	Lead,cadmium
K066	Sludge from treatment of process wastewater and/or acid plant blowdown from primary zinc production	Lead, cadmium
K067	Electrolytic anode slimes/sludges from primary zinc production	Lead, cadmium
K068	Cadmium plant leachate residue (iron oxide) from primary zinc production	Lead, cadmium
K069	Emission control dust/sludge from secondary lead smelting	Hexavalent chromium, lead, cadmium
K100	Waste leaching solution from acid leaching of emission control dust/sludge from secondary lead smelting	Hexavalent chromium, lead, cadmium
F006	Wastewater treatment sludge from electroplating operations	Hexavalent chromium, cadmium

Federal Register, May 19, 1980 (45 FR 33123-33127 and 33136-33137) and November 12, 1980 (45 FR 74884-74894).

TABLE 5. RESULTS OF APPLYING THE INORGANIC SCREEN

Waste Streams	ID No.	Heavy Metals	Metal Conc. (kg/kkg)	No. of Plants	Waste Stream Generation Rates (kg)			Cumulative Waste Limit at CEC 15 (kg/ha)	Total Land Area Required (ha)	LLC*	Land Area Required for LLC	Research Priority
					Total Annual	Average Annual	Total Amount Generated/ Plant in 10 Yrs.					
Wastewater treatment from the production of chrome yellow and orange pigments	K002	Cr Pb	5.25 21.38	Unknown								Low
Wastewater treatment from the production of molybdate orange pigments	K003	Cr Pb	6.00 14.15	Unknown								Low
Wastewater treatment from the production of zinc yellow pigments	K004			Unknown								Low
Wastewater treatment sludge from the production of chrome green pigments	K005	Cr^{+6} Pb	0.43 1.7	Unknown								Low
Wastewater treatment sludge from the production of chrome oxide green pigments (anhydrous and hydrated)	K006	Cr	13.2	Unknown								Low
Wastewater treatment sludge from the production of iron blue products	K007	Cr^{+6}		Unknown								Low
Oven residue from the production of chrome oxide green pigments	K008	Cr^{+6}	5.5	Unknown								Low

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(continued)

TABLE 5. RESULTS OF APPLYING THE INORGANIC SCREEN

Waste Streams	ID No.	Heavy Metals	Metal Conc. (kg/kkg)	No. of Plants	Waste Stream Generation Rates (kg) Total Annual	Average Annual	Total Amount Generated/ Plant in 10 Yrs.	Cumulative Waste Limit at CEC 15 (kg/ha)	Total Land Area Required (ha)	LLC*	Land Area Required for LLC	Research Priority
Chrome pigments	K002-K008	Cr	43-13	Unknown	2100-2600 MT (total)	630-780 MT (based on 2 plants)	2,710-101,000	500	45.4-203	Cr	45.4-203	Low
		Pb	1.7-21		1260-1560 MT (from 2 plants)		10,700-164,000	2000	5.3-82			
Dissolved air flotation (DAF) float from the petroleum refining industry	K048	Cr^{+6}	28-260 mg/kg	~300	8.4 MT/yr (dry wt.)	28kg/yr	280	500	.56	Cr^{+6}	.56	High
		Pb	2.3-1250 mg/kg		0.4 MT/yr (dry wt.)	1.3 kg/yr	13	2000	.65			
Slop oil emulsion solids from the petroleum industry	K049	Cr^{+6}	1-1750 mg/kg	300	36,506 kg	122 kkg	1.2-2130	500	.002-4.26	Cr^{+6}	.002 -4.26 ha	High
		Pb	.25-580 mg/kg				0.3-706	2000	0-.35			
Heat exchanger bundle cleaning sludge from the petroleum refining industry	K050	Cr^{+6}	310 mg/kg	~300	.4 MT/yr (dry wt.)	1.33 kg	13.3	500	0.27	Cr^{+6}	.0267	High
API separator sludge from the petroleum refining industry	K051	Cr^{+6}	.1-6790 mg/kg	~300	18.8 MT/yr Cr & Pb dry weight	58.7 kg	587	500	1.2	Cr^{+6}	1.174	High
		Pb	.25-1290 mg/kg			4 kg	40	2000	.02			
Tank bottoms (leaded) from the petroleum refining industry	K052	Pb	158-1420 mg/kg	~300	1.1 MT/yr Pb (dry wt.)	3.67 kg	36.7	2000	0.02	Pb	0.02	High

(continued)

TABLE 5. RESULTS OF APPLYING THE INORGANIC SCREEN

Waste Streams	ID No.	Heavy Metals	Metal Conc. (kg/kkg)	No. of Plants	Waste Stream Generation Rates (kg) Total Annual	Average Annual	Total Amount Generated/ Plant in 10 Yrs.	Cumulative Waste Limit at CEC 15 (kg/ha)	Total Land Area Required (ha)	LLC[a]	Land Area Required for LLC	Research Priority
Dissolved air flotation, slop oil emulsion solids, heat exchanger bundle cleaning. Sludge, API separator sludge, tank bottoms (leaded) from the petroleum refining industry	K048-K052	Cr	0.1-6790	300	66,610 kkg dry	222 kkg	2.2-15,000	500	1-30	Cr	30	High
		Pb	0.2-1420				2.2-3,150	2000	1-1.6			
Emission control dust/sludge from the primary production of steel in electric furnaces	K061	Cr	18,400 (dusts)	54	321,000 kkg dust/ 16,000 kkg sludge	5944 kkg dust/ 296 kkg sludge	1,100,000	500	2200	Cr	2200	Low
		Pb	4220-7000 (dusts)				470,000-779,000	2000	235-390			
		Cr	2746 (sludge)				8,100	500	16.2			
		Pb	8000 (sludge)				24,000					
Spent pickle liquor from steel finishing operations	K062	Cr^{+6}	2-4250 ppm	240	5×10^6 kkg	2.1x104 kkg	420-892,000	500	.84-1784	Cr	.84-1784	Low
		Pb	1-1550				210-325,000	2000	0.1-162			
Acid plant blow down slurry/ sludge resulting from the thickening of blowdown slurry from primary copper production	K064	Pb	8000	17	128,400 kkg	7550 kkg	600,000	2000	300	Cd	2000	Low
		Cd	520				39,000	20	2000			
		Hg	0.8				6	8	0.75			
		Cr	50				380	500	0.8			
		Se	30				230					
Surface impoundment solids contained in and dredged from the surface impoundment at primary lead smelting facilities	K065	Pb	16-50 ppm	3-4	44,190 kkg/yr	14,730 kkg (3 plants)	2340-7300	2000	1.2 -3.6	Cd	65.6-109.5	Low
		Cd	0.9-15 ppm				131-2190	20	65.6-109.5			

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(continued)

TABLE 5. RESULTS OF APPLYING THE INORGANIC SCREEN

Waste Streams	ID No.	Heavy Metals	Metal Conc. (kg/kkg)	No. of Plants	Waste Stream Generation Rates (kg) Total Annual	Average Annual	Total Amount Generated/ Plant in 10 Yrs.	Cumulative Waste Limit at CEC 15 (kg/ha)	Total Land Area Required (ha)	LLC[a]	Land Area Required for LLC	Research Priority
Sludge from treatment of process wastewater and/or acid plant blowdown from primary zinc production	K066	Pb(pyro)	4300	2 pyro metallurgical	9081 kkg pyro metallurgical	4541 pyro-metallurgical	200,000	2000	100	Pb	16,500	Low
		Cd(pyro)	640-2000				30,000-93,000	20	1500-4650			
		Pb (electro)	98-18,000	5 electrolytic	98 kkg electrolytic	130 electrolytic	1,787-330,000	2000	0.9-16,500			
		Cd (electro)	<10-550				<182-10,000	20	9.1-500			
Electrolytic anode slimes and sludges from primary zinc production	K067	Cd	12-1400 ppm	4	2360 kkg	590 kkg	71-8260	20	36-413	Pb	263-501	Low
		Pb	89,000-170,000				525,000-1,000,000	2000	263-501			
Cadmium plant leachate residue (iron oxide) from primary zinc production	K068	Pb	215,000	7	545 kkg	78 kkg	167,700	2000	84	Pb	84	Low
		Cd	280				218	20	11			
Emission control dust/sludge from secondary lead smelting	K069-K100	Cr[+6]	150 (dusts) 30 (sludges)	67 dusts 15 sludges	7,151,000 kkg sludges 120,007,100 kkg dusts	476,775 kkg sludges	2,700,000 143,000	500 500	5400 286			Low
		Pb	53,000 (sludge) 120,000 (dust)				253,000,000 2,100,000,000	2000 2000	115,000 1,050,000	Pb	1,050,000	
		Cd	340 (sludge) 900 (dust)			1,791,150 kkg dusts	1,600,000 16,000,000	20 20	80,000 800,000			

TABLE 6. HIGH AND MODERATE POTENTIAL CANDIDATES FOR LAND TREATMENT RESEARCH

EPA No.	Waste stream description	Priority
Inorganics		
K048 - K052	Petroleum refining wastes (hazardous due to chromium and lead)	High
Organics		
K009	Still bottoms from production of acetaldehyde from ethylene	High
K010	Distillation side cuts from the production of acetaldehyde from ethylene	High
K013	Bottom stream from the acetonitrile column in the production of acrylonitrile	High
K014	Bottoms from the acetonitrile purification column in the production of acrylonitrile	High
K093	Distillation light ends from the production of phthalic anhydride from ortho-xylene	High
K026	Stripping still tails from the productionof methyl ethyl pyridines	High
K036	Still bottoms from toluene reclamation distillation in the production of disulfoton	High
K037	Wastewater treatment sludges from the production of disulfoton	High
F004	Spent cresols, cresylic acid, and nitrobenzene, and still bottoms from recovery of these solvents	Moderate-High
K047	Heavy ends (still bottoms) from the purification column in the production of epichlorohydrin	Moderate-High
K011	Bottom stream from the wastewater stripper in the production of acrylonitrile	Moderate
K015	Still bottoms from the distillation of benzyl chloride	Moderate
K023	Distillation light ends from the production of phthalic anhydride from naphthalene	Moderate

(Continued)

TABLE 6 (continued)

EPA No.	Waste stream description	Priority
Organics		
K094	Distillation bottoms from the production of phthalic anhydride from orthoxylene	Moderate
K038	Wastewater from the washing and stripping of phorate production	Moderate
K039	Filter cake from the filtration of diethylphosphorodithioic acid in the production of phorate	Moderate
K040	Wastewater treatment sludge from the production of phorate	Moderate
Mixed organic/inorganic		
K060	Ammonia still lime sludge from coking operations	High

TABLE .7. WASTE STREAMS LISTED AS HAZARDOUS BECAUSE OF ORGANIC CHEMICAL COMPONENTS

EPA hazardous waste No.	Waste stream description	Hazardous constituents for which waste stream is listed
F001	The following spent halogenated solvents used in degreasing tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons, and sludges from the recovery of these solvents in degreasing operations.	Tetrachloroethylene, methylene chloride trichloroethylene, 1,1,1-trichloroethane, carbon tetrachloride, chlorinated fluorocarbons.
F002	The following spent halogenated solvents: tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, orthodicholorobenzene, and trichlorofluoromethane; and the still bottoms from the recovery of these solvents.	Tetrachloroethylene, methylene chloride, trichloro-ethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, trichlorofluoromethane.
F003	The following spent non-halogenated solvents: zylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol, and the still bottoms from the recovery of these solvents.	NA
F004	The following spent non-halogenated solvents: cresols and cresylic acid, and nitrobenzene, and the still bottoms from the recovery of these solvents.	Cresols and cresylic acid, nitrobenzene.
F005	The following spent non-halogenated solvents: toluene, methyl ethyl ketone, carbon disulfide, isobutanol, and pyridine; and the still bottoms from the recovery of these solvents.	Toluene, methyl ethyl ketone, carbon disulfide, isobutanol, pyridine.

(continued)

TABLE 7 (continued)

EPA hazardous waste No.	Waste stream description	Hazardous constituents for which waste stream is listed
K001	Bottom sediment sludge from the treatment of waste-waters from wood preserving processes that use creosote and/or pentachlorophenol.	Pentachlorophenol, phenol, 2-chlorophenol, p-chloro-m-cresol, 2,4-dimethylphenyl, 2-4,dinitrophenol, trichlorophenols, tetrachlorophenols, 2,4-dinitrophenol, creosote, chrysene, naphthalene, fluoranthene, benzo(b)fluoranthene, benzo(a)anthracene, dibenz(a)-anthracene, acenaphthalene.
K009	Distillation bottoms from the production of acetaldehyde from ethylene.	Chloroform, formaldehyde, methylene, chloride, methyl chloride, paraldehyde, formic acid.
K010	Distillation side cuts from the production of acetaldehyde from ethylene.	Chloroform formaldehyde, methylene chloride, methyl chloride, paraldehyde, formic acid, chloroacetaldehyde.
K011	Bottom stream from the wastewater stripper in the production of acrylonitrile.	Acrylonitrile ,acetonitrile, hydrocyanic acid
K013	Bottom stream from the acetonitrile column in the production of acrylonitrile.	Hydrocyanic acid, acrylonitrile, acelonitrile.
K014	Bottoms from the acetonitrile purification column in the production of acrylonitrile.	Acetonitrile, acrylamide.
K015	Still bottoms from the distillation of benzyl chloride	Benzyl chloride , chlorobenzene, toluene, benzotrichloride.

(continued)

TABLE 7 (continued)

EPA hazardous waste No.	Waste stream description	Hazardous constituents for which waste stream is listed
K016	Heavy ends or distillation residues from the production of carbon tetrachloride.	hexachlorobenzene, hexachlorobutadiene, carbon tetrachloride, hexachloroethane, perchloroethylene.
K017	Heavy ends (still bottoms) from the purification column in the production of epichlorohydrin.	Epichlorohydrin ,chloroethers [bis(chloromethyl) ether and bis-(2-chloroethyl) ethers], trichloropropane, dichloropropanols.
K018	Heavy ends from the fractionation column in ethyl chloride production.	1,2-dichloroethane, trichloroethylene, hexachlorobutadiene, hexachlorobenzene.
K019	Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production.	Ethylene dichloride, 1,1,1-trichloroethane, 1,1,2-trichloroethane, tetrachloroethanes (1,1,2,2-tetrachloroethane and 1,1,1,2-tetrachloroethane), trichloroethylene, tetrachloroethylene, carbon tetrachloride, chloroform, vinyl chloride, vinylidene chloride.
K020	Heavy ends from the distillation of vinyl chloride monomer production.	Ethylene dichloride, 1,1,1-trichloroethane, 1,1,2-trichloroethane, tetrachloroethanes (1,1,2,2,-tetrachloroethane and 1,1,1,2-tetrachloroethane), trichloroethylene, tetrachloroethylene, carbon tetrachloride, chloroform, vinyl chloride, vinylidene chloride.

(continued)

TABLE 7 (continued)

EPA hazardous waste No.	Waste stream description	Hazardous constituents for which waste stream is listed
K021	Aqueous spent antimony catalyst waste from fluoromethanes production.	Antimony, carbon tetrachloride, chloroform.
K022	Distillation bottom tars from the production of phenol/acetone from cumene.	Phenol, tars (polycyclic aromatic hydrocarbons).
K023	Distillation light ends from the production of phthalic anhydride from naphthalene.	Phthalic anhydride, maleic anhydride.
K024	Distillation bottoms from the production of phthalic anhydride from naphthalene.	Phthalic anhydride, 1,4-naphthoquinone.
K093	Distillation light ends from the production of phthalic anhydride from orthoxylene.	Phthalic anhydride, maleic anhydride.
K094	Distillation bottoms from the production of phthalic anhydride from orthozylene.	Phthalic anhydride.
K025	Distillation bottoms from the production of nitrobenzene by the nitration of benzene.	Meta-dinitrobenzene, 2,4-dinitrotoluene.
K026	Stripping still tails from the production of methyl ethyl pyridines.	Paraldehyde, pyridines, 2-picoline.
K027	Centrifuge and distillation residues from toluene diisocyanate production.	Toluene diisocyanate, toluene-2,4-diamine.
K028	Spent catalyst from the hydrochlorinator reactor in the production of 1,1,1-trichloroethane.	1,1,1-trichloroethane, vinyl chloride.
K029	Waste from the product stream stripper in the production of 1,1,1-trichloroethane.	1,2-dichloroethane, 1,1,1-trichloroethane, vinyl chloride, vinylidene chloride, chloroform.

(continued)

TABLE 7 (continued)

EPA hazardous waste No.	Waste stream description	Hazardous constituents for which waste stream is listed
K095	Distillation bottoms from the production of 1,1,1-trichloroethane.	1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane.
K096	Heavy ends from the heavy ends column from the production of 1,1,1-trichloroethane.	1,2-dichloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane.
K030	Column bottoms or heavy ends from the combined production of trichloroethylene and perchloroethylene.	Hexachlorobenzene, hexachlorobutadiene, hexachloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, ethylene dichloride.
K032	Wastewater treatment sludge from the production of chlordane.	Hexachlorocyclopentadiene.
K033	Wastewater and scrub water from the chlorination of cyclopentadiene in the production of chlordane.	Hexachlorocyclopentadiene.
K034	Filter solids from the filtration of hexachlorocyclopentadiene in the production of chlordane.	Hexachlorocyclopentadiene.
K097	Vacuum stripper discharge from the chlordene chlorinator in the production of chlordane.	Chlordane, heptachlor.
K035	Wastewater treatment sludges generated in the production of creosote.	Creosote, chrysene, naphthelene, fluoranthene benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd) pyrene, benzo(a)anthracene, dibenzo(a)anthracene, acenaphthalene.

(continued)

TABLE 7 (continued)

EPA hazardous waste No.	Waste stream description	Hazardous constituents for which waste stream is listed
K036	Still bottoms from toluene reclamation distillilation in the production of disulfoton.	Toluene, phosphorodithioic and phosphorothioic acid esters.
K037	Wastewater treatment sludges from the production of disulfoton.	Toluene, phosphorodithioic and phosphorothioic acid esters.
K038	Wastewater from the washing and stripping of phorate production.	Phorate, formaldehyde, phosphorodithioic and phosphorothioic acid esters.
K040	Wastewater treatment sludge from the production of phorate.	Phosphorodithioic and phorphorothioic acid esters.
K041	Wastewater treatment sludge from the production of toxaphene	Toxaphene.
K098	Untreated process wastewater from the production of toxaphene.	Toxaphene.
K042	Heavy ends or distillation residues from the distillation of tetrachlorobenzene in the production of 2,4,5-T.	Hexachlorobenzene, orthodichlorobenzene.
K043	2,6-Dichlorophenol waste from the production of 2,4-D.	2,4-dichlorophenol, 2,6-dichlorophenol, 2,4,6-trichlorophenol.
K099	Untreated wastewater from the production of 2,4-D.	
K044	Wastewater treatment sludges from the manufacturing and processing of explosives.	NA
K045	Spent carbon from the treatment of wastewater containing explosives.	NA

(continued)

TABLE 7 (continued)

EPA hazardous waste No.	Waste stream description	Hazardous constituents for which waste stream is listed
K046	Wastewater treatment sludges from the manufacturing, formulation and loading of lead-based initiating compounds.	Lead
K047	Pink/red water from TNT operations.	NA
K060	Ammonia still lime sludge from coking operations.	Cyanide, naphthalene, phenolic compounds, arsenic.
. . . . .		

NA = Waste is hazardous because it fails the test for the characteristic of ignitability, corrosivity, or reactivity.

Federal Register, May 19, 1980 (45 FR 33123-33137 and 33136-33137) and November 12, 1980 (45 FR 74884-74894).

TABLE 8. RESULTS OF APPLYING THE ORGANIC SCREEN*

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams +	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Annual Waste Stream Generation Rates (tons/year) Average/ Plant	Other Relevant Ranking Factors	Research Priorities
The following spent halogenated solvents used in degreasing tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride and chlorinated fluorocarbons, and sludges from the recovery of these solvents in degreasing operations	F001	Tetrachloroethylene	N.S.	0	II	460,000 (using halogenated solvents)	99,000	215	The chlorinated solvents in common use are quite volatile and therefore present a potential air pollution problem in land treatment-systems.	Low
		Methylene chloride	N.S.	+4						
		Trichloroethylene	N.S.	+2						
		1,1,1-trichloroethane	N.S.	0						
		Carbon tetrachloride	N.S.	+2						
		Chlorinated fluorocarbons	N.S.	0						
The following spent halogenated solvents: tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, orthodichlorobenzene, and trichlorofluoromethane, and the still bottoms from the recovery of these solvents	F002	Tetrachloroethylene	N.S./N.A.	0	II	Vast	Vast	--	Same as F001	Low
		Methylene chloride	N.S./N.A.	+4						
		Trichloroethylene	N.S./N.A.	+2						
		1,1,1-trichloroethane	N.S./N.A.	+2						
		Chlorobenzene	N.S./N.A.	+2						
		1,1,2-trichloro-1,2,2,trifluroethane	N.S./N.A.	0						
		Orthodichlorobenzene	N.S./N.A.	+2						
		Trichlorofluoromethane	N.S./N.A.	0						
The following spent non-halogenated solvents: xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol, and the still bottoms from the recovery of these solvents	F003	Not listed in register	N.S.		I	Many in 12 industries	Vast	--	The basis for listing is ignitability; which represents a potential fire hazard in a land treatment system.	Low
		Xylene	N.S.	+4						
		Acetone	N.S.	+4						
		Ethyl acetate	N.S.	+4						
		Ethyl benzene	N.S.	+4						
		Ethyl ether	N.S.	+4						
		n-butyl alcohol	N.S.	+4						
		Cyclohexanone	N.S.	+4						
The following spent non-halogenated solvents: cresols and cresylic acid and nitrobenzene and the still bottoms from recovery of these solvents.	F004	Cresols and Cresylic	N.S.	+4	I	?	N.S.		At high concentrations, cresols can inhibit biological activity in soils. Research is needed on allowable limits to permit design of application quantity and frequency.	Medium to High
		Nitrobenzene	N.S.	+4						

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TABLE 8 (continued)

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams+	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Average/ Plant	Other Relevant Ranking Factors	Research Priorities
The following spent non-halogenated solvents: cresols and cresylic acid and nitrobenzenes and the still bottoms from recovery of these solvents	F004	Cresols and Cresylic Acids	N.S.	+4	I	?	N.S.	--	At high concentrations, cresols can inhibit biological activity in soils. Research is needed on allowable limits to permit design of application quantity and frequency	Medium to High
		Nitrobenzene	N.S.	+4						
The following spent non-halogenated solvents: toluene, methyl ethyl ketone, carbon disulfide, isobutanol and pyridine, and the still bottoms from the recovery of these solvents	F005	Toluene	N.S.	+4	I	?	Massive	--	The waste streams are listed because of ignitability. They therefore represent a potential fire hazard in a land treatment system.	Low
		Methyl ethyl ketone	N.S.	+4						
		Carbon disulfide	N.S.	+4						
		Isobutanol	N.S.	+4						
		Pyridine	N.S.	+4						
		Methanol	N.S.							
		Methyl isobutyl ketone	N.S.							
Bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote and/or pentachlorophenol	K001	Pentachlorophenol	34	-4	III	415	800-1500 MT/yr	1.93-3.61 MT/yr	Land treatment is currently being applied to this waste stream at numerous facilities.	High
		Phenol		+4						
		2-chlorophenol		+4						
		p-chloro-m-cresol		+4						
		2,4-dimethylphenyl-2,4-dinitrophenol	24	-2						
		Trichlorophenols		+4						
		Tetrachlorophenols		-4						
		2-4,dinitrophenol		-2						
		Creosote	10,000	+4						
		Chryuene		0						
		Naphthalene		+4						
		Fluoranthene		-2						
		Benzo(b)fluoranthrene		-2						
		Benzo(a)pyrene		-2						
		Indeno(1,2,3cd)pyrene		-2						
		Benz(a)anthracene		-2						
		Dibenz(a)anthracene		-2						
		Acenaphthalene		+4						

(continued)

TABLE 8 (continued)

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams +	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Annual Waste Stream Generation Rates (tons/year) Average/ Plant	Other Relevant Ranking Factors	Research Priorities
Distillation bottoms from the production of acetaldehyde from ethylene	K009	Chloroform	5 g/L	+2	1	3	565,000 MT/yr	183,333 MT/yr	The annual organic loading on a 100-acre site dedicated to the wastes from a single plant would be 8%. Rates of degradation would need to be established empirically to determine quantity and frequency of allowable application. The waste is 97% water, and hydraulic loading for the quantities generated might be excessive	High
		Formaldehyde		+4						
		Methylene chloride		+4						
		Methyl chloride		+4						
		Paraldehyde	2 g/L	+4						
		Formic acid		+4						
		Acetic acid	17 g/L							
		Acetyl chloride	5 g/L							
		Chloral	2.6 g/L							
		Water	97%							
Distillation side cuts from the production of acetaldehyde from ethylene	K010	Chloroform	7.8 g/L	+2	1	1	25,000 MT/yr	25,000 MT/yr	Annual organic loading on a 100-acre site would be 1%.	High
		Formaldehyde		+4						
		Methylene chloride		+4						
		Methyl chloride		+4						
		Paraldehyde	N.S.	+4						
		Formic acid	N.S.	+4						
		Chloroacetaldehyde	21.57 g/L	+2						
		Acetaldehyde	30.6 g/L							
		Acetic acid	2.35 g/L							
		Acetyl chloride	13.9 g/L							
		Water	90%							
Bottom stream from the wastewater stripper in the production of acrylonitrile	K011	Acrylonitrile	500 mg/L	+4	1	4	6000 mm lbs/yr	1500 mm lbs/yr	Quantity per plant could be excessive for a 100-acre site.	Moderate
		Acetonitrile	3000 mg/L	+4						
		Hydrocyanic acid	7000 mg/L	+4						
		Sulfates	32,000							
		Ammonia	15,000							
		Additional Non-toxic solids	40,000							
		Water	90%							

(continued)

TABLE 8 (continued)

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams+	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Annual Waste Stream Generation Rates (tons/year) Average/ Plant	Other Relevant Ranking Factors	Research Priorities
Bottom stream from the acetonitrile column in the production of acrylonitrile	K013	Hydrocyanic acid	225	+4	I	4	675 MM lbs/yr	169 MM lbs/yr	--	High
		Acrylonitrile	<10	+4						
		Acetonitrile	35	+4						
Bottoms from the acetonitrile column in the production of acrylonitrile	K014	Acetonitrile	N.S.	+4	I	4	N.S.	N.S.	Although quantities are not specified, they are not expected to be high	High
		Acrylamide	N.S.	+4						
Still bottoms from the distillation of benzyl chloride	K015	Benzylchloride, Benzotrichloride	0.008 kg/ kg total waste	+2	II	N.S.	5.3 million kg/yr	--	--	Moderate
		Chlorobenzene		+2						
		Toluene	N.S.	+4						
		Heavier chlorinated benzenes								
		Total hazardous constituents	0.05 kg/ kg total waste							
Heavy ends or distillation residues from the production of carbon tetrachloride	K016	Hexachlorobenzene		-4	III	10	8.6×10^6 lbs/yr	8.6×10^5 lbs/yr.	Annual organic loading on a 100-acre site would be 0.5% per plant	Low
		Hexachlorobutadiene		+4						
		Carbon tetrachloride		+2						
		Hexachloroethane		+4						
		Perchloroethylene (tetrachloroethylene)		0						
Heavy ends (still bottoms) from the purification column in the production of epichlorohydrin	K017	Epichlorohydrin	2	+4	II	3	12,500	4,100	Plants are located in Texas and Louisiana where frost-free periods favors land treatment. Organic loading per plant per year would be about 5%.	Moderate to High
		Chloroethers [bis(chloromethyl) ether and bis(2-chloroethyl) ethers]	14	+4						
		Trichloropropane	70	0						
		Dichloropropanols	10	+4						

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(continued)

TABLE 8 (continued)

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams +	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Annual Waste Stream Generation Rates (tons/year) Average/ Plant	Other Relevant Ranking Factors	Research Priorities
Heavy ends from the fractionation column in ethyl chloride production	K018	1,2-dichloroethane	22	0	III	6	35,000 MT/yr	5,833 MT/yr	--	Low
		Trichloroethylene	32	+2						
		Hexachlorobutadiene / Hexachlorobenzene	43	+4 / -4						
		Ethyl chloride	3							
Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production	K019	Ethylene dichloride	7.91 lbs/mt of ethylene dichloride	+2	III	20	77,000-170,000 MT/yr (K019 and K020)	3,850-8,500 MT/yr	--	Low
		1,1,1-trichloroethane		0						
		1,1,2-trichloroethane	9.08 lb/mt	-2						
		Tetrachloroethanes (1,1,2,2-tetrachloroethane and 1,1,1,2-tetrachloroethane	10.18 lb/mt	-2						
		Trichloroethylenes		+2						
		Tetrachloroethylene		0						
		Carbon tetrachloride		+2						
		Chloroform		+2						
		Vinyl chloride		+2						
		Vinylidene chloride		+2						
Heavy ends from the distillation of vinyl chloride in vinyl chloride monomer production	K020	Ethylene dichloride		+2	III	20	77,000-170,000 MT/yr (K019 and K020)	3,850-8,500 MT/yr	--	Low
		1,1,1-trichloroethane		0						
		1,1,2-trichloroethane		-2						
		Tetrachloroethanes - (1,1,2,2-tetrachloroethane and 1,1,1,2-tetrachloroethane)		-2						
		Trichloroethylene		+2						
		Tetrachloroethylene		0						
		Carbon tetrachloride		+2						
		Chloroform		+2						
		Vinyl chloride		+2						
		Vinylidene chloride		+2						

(continued)

TABLE 8 (continued)

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams +	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Annual Waste Stream Generation Rates (tons/year) Average/ Plant	Other Relevant Ranking Factors	Research Priorities
Distillation bottom tars from the production of phenol/acetone from cumene	K022	Phenol	0.75 g/kg	+4	III	11	45,000-100,000	4,100 - 9,100 MT/yr	--	Low
		Tars (polycyclic aromatic hydrocarbons	50-110 g/kg phenol product	-2						
		Acetophenone	1.9 g/kg product							
		Cumylphenol	.85 g/kg product							
Distillation light ends from the production of phthalic anhydride from napthalene	K023	Phthalic anhydride	0.3	+4	I	Located in seven states	7273 MT/yr. (light ends and heavy bottoms)	No more than 1040 MT/yr.	Unknown quantity of polynuclear aromatic tars which could be highly persistent	Moderate
		Maleic anhydride	0.2	+4						
		Quinones	N.S.	+4						
		Naphthoquinones	N.S.	+4						
		Polynuclear aromatic hydrocarbons	N.S.	+4						
Distillation bottoms from the production of phthalic anhydride from napthalene	K024	Phthalic anhydride	0.2	+4	I	Located in seven states	7300 MT/yr.	No more than 1050 MT/yr.	Polynuclear aromatic tars are likely to be very persistent	Moderate
		1,4-naphthoquinones	0.2	+4						
		Maleic anhydride	N.S.							
		Polynuclear aromatic tars								
Distillation light ends from the production of phthalic anhydride from orthoxylene	K093	Phthalic anhydride		+4	I	7	2300 MT/yr.	325 MT/yr.	--	High
		Maleic anhydride		+4						
Distillation bottoms from the production of phthalic anhydride from orthoxylene	K094	Phthalic anhydride	45%	+4	I	7	910 MT/yr.	130 MT/yr	The tars have not been characterized and may be highly persistent.	Moderate
Distillation bottoms from the production of nitrobenzene by nitration of benzene	K025	Meta-dinitrobenzene	94	0	III	7	160-200 MT/yr	23-28 MT/yr	--	Low
		2,4,dinitrotoluene nitrobenzene	6							

(continued)

TABLE 8 (continued)

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams +	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Annual Waste Stream Generation Rates (tons/year) Average/ Plant	Other Relevant Ranking Factors	Research Priorities
Stripping still tails from the production of methyl ethyl pyridines	K026	Paraldehyde	79	+4	I	N.S.	600 MT/ yr.	--	--	High
		Pyridines } 2-picoline }	6.6	+4 +4						
		Sulfuric acid	7.9							
		Phenol	.0008							
		Soluble acetate	6.6							
Centrifuge and distillation residues from toluene diisocyanate production	K027	Toluene diisocyanate	3%	+4	III	8	6000 MT/ yr.	750 MT/ yr.	Toluene diisocyanate is highly reactive with water. Reaction is very rapid, exothermic, and violent	Low
		Toluene-2,4-diamine		+4						
		Ferric chloride	6%							
		Polynuclear aromatic tars	90%	-2						
Spent catalyst from the hydrochlorinator reactor in the production of 1,1,1-trichloroethane via the vinyl chloride process	K028	1,1,1-trichloroethane	minor	0	III	4	N.S.		--	Low
		Vinyl chloride	minor	+2						
		Polymeric tars	minor	-2						
		NH_4Cl-$FeCl_3$-NH_3 complex								
Waste from the steam stripper in the production of 1,1,1-trichloroethane	K029	1,2-dichloroethane	17	0	III	4	1400 MT/ yr.	340 MT/ yr.	--	Low
		1,1,1-trichloroethane	83	0						
		Vinyl chloride	--	+2						
		Vinylidene chloride	--	+2						
		Chloroform	--	+2						
Distillation bottoms from the production of 1,1,1,-trichloroethane	K095	1,1,2-trichloroethane	38%	0	III	4	6.9×10^{13} MT/yr	1.7×10^{13} MT/yr	--	Low
		1,1,1,2-tetrachloroethane		-2						
Heavy ends from the heavy ends column from the production of 1,1,1-trichloroet-ane	K096	1,1,2,1-tetrachloroethane hexachloroethane	57%	-2						
		Pentachloroethane	1.3%							
		1,1-dichloroethane	trace							
		1,2-dichloroethane	1.3%							
		1,1,1-trichloroethane	2.2%							

(continued)

TABLE 8 (continued)

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams +	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Average/ Plant	Other Relevant Ranking Factors	Research Priorities
Column bottoms or heavy ends from the combined production of trichloroethylene and perchloroethylene	K030	Hexachlorobenzene	20.0%	-4	III	10	14,780 MT/ yr.	1,478 MT/ yr.	--	Low
		Hexachlorobutadiene	33.8%	+4						
		Hexachloroethane	4.0%	+4						
		1,1,1,2-tetrachloro-ethane	6.3%	-2						
		1,1,2,2-tetrachloro-ethane	23.0%	-2						
		Ethylene dichloride	0.6%	+2						
Wastewater treatment sludge from the production of chlordane	K032	Hexachlorocyclo-pentadiene	N.S.	+4	I	1	N.S.	--	Although the parent compound is not highly persistent, the metabolites may be	Low
Wastewater and scrub water from the chlorinator of cyclopentadiene in the production of chlordane	K033	Hexachlorocyclo-pentadiene	N.S.	+4	I	1	N.S.	--	--	Low
Filter solids from the filtration of hexachlorocyclopentadiene in the production of chlordane	K034	Hexachlorocyclo-pentadiene	N.S.	+4	I	1	N.S.	--		Low
Vacuum stripper discharge from the chlordane chlorinator in the production of chlordane	K097	Chlordane		-4	III	1	13,600 MT/yr (197?)			Low
		Heptachlor		+4						
Wastewater treatment sludges generated in the production of creosote	K035	Creosote	N.S.	+4	III	25	27,300-52,300 MT/yr	2,637 MT/ yr.		Low
		Chrysene	N.S.	0						
		Napthalene	N.S.	+4						
		Fluoranthene	N.S.	-2						
		Benzo(b)fluoranthene	N.S.	-2						
		Benzo(a)pyrene	N.S.	-2						
		Indeno (1,2,3-cd)pyrene	N.S.	-2						
		Benzo(a)anthracene	N.S.	-2						
		Dibenzo(a)anthracene	N.S.	-2						
		Acenapthalene	N.S.	+4						

(continued)

TABLE 8 (continued)

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams +	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Annual Waste Stream Generation Rates (tons/year) Average/ Plant	Other Relevant Ranking Factors	Research Priorities
Still bottoms from toluene reclamation distillation in the production of disulfoton	K036	Toluene	N.S.	+4	I	1 (Kansas City)	120 MT/ yr.	120 MT/ yr.	--	High
		Phosphorodithioic and phosphorothioic acid esters	N.S.	+2						
			--	+2						
Wastewater treatment sludges from the production of disulfoton	K037	Toluene	N.S.	+4	I	1	120 MT/ yr.	120 MT/ yr.	--	High
		Phosphordithioic and phosphorothioic acid esters	N.S.	+2						
			N.S.	+2						
Wastewater from washing and stripping of phorate production	K038	Phorate		+2	II	--	N.S.	--	--	Moderate
		Formaldehyde		+4						
		Phosphorodithioic and		+2						
		Phosphorothioic acid esters		+2						
Filter cake from the filtration of diethylphosphorodithioic acid in the production of phorate	K039	Phosphorodithioic and phosphorothioic acid esters		+2	II	2 (Missouri)	N.S.	--	--	Moderate
Wastewater treatment sludge from the production of phorate	K040	Phorate		+2	II	2	N.S.	--	--	Moderate
		Formaldehyde		+4						
		Phosphorodithioic and phosphorothioic acid esters		+2						
Wastewater treatment sludge from the production of toxaphene	K041	Toxaphene	10,000 mg/kg	-4	III	2	2,800 MT/ yr.	1,400 MT/ yr.	--	Low
Untreated process waste water from the production of toxaphene	K098	Toxaphene		-4	III	2	Unknown	Unknown	--	Low

(continued)

TABLE 8 (continued)

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Average/ Plant	Other Relevant Ranking Factors	Research Priorities
Heavy ends or distillation residues from the distillation of tetrachlorobenzene in the production of 2,4,5-T	K042	Hexachlorobenzene	N.S.	-4	III	N.S.	N.S.		--	Low
		Ortho-dichlorobenzene	N.S.	+2						
2,6-dichlorophenol waste from the production of 2,4-D	K043	2,4-dichlorophenol	N.S.	+4	I	N.S.	N.S.		Chlorophenol wastes often contain dioxin. Although there is evidence that dioxin is biodegradable, it is unlikely that land treatment would be allowed	Low
		2,6-dichlorophenol	N.S.	+4						
		2,4,6-trichlorophenol	N.S.	+4						
		Chlorophenol polymers	N.S.							
Wastewater treatment sludges from the manufacture and processing of explosives	K044	TNT		Not Evaluated		~150	5.79×10^6 MT (dry)	38,600		
		Nitroglycerin								
		Nitrocellulose								
		Cyclotrimethylamine								
		Trinitroamine								
Spent carbon from the treatment of wastewater containing explosives	K045	Not listed				~150	5.8×10^6 MT total industry wastes	--		
		TNT								
		Nitroglycerine								
		Nitrocellulose								
		Cyclotrimethylamine								
		Trinitroamine								
Pink/red waste from TNT operations	K047	Not listed								
		TNT	up to 150 ppm	--		--	--	--		

*For information on waste streams excluding persistence:

"Background Document - Resource Conservation and Recovery Act, Subtitle C - Identification and Listing of Hazardous Waste," U.S. Environmental Protection Agency, Office of Solid Waste, unpublished report dated May 2, 1980.

For information on persistence, the source is Arthur D. Little, Inc.

+ I - Low persistence
II - Moderately persistent
III - Highly persistent

TABLE 9. RESULTS OF APPLYING THE INORGANIC AND ORGANIC SCREENS*

Waste Streams	ID No.	Waste Stream Component	Conc.	Persistence Scores for Hazardous Components	Persistence Category for Waste Streams	No. of Plants	Annual Waste Stream Generation Rates (tons/year) Total	Annual Waste Stream Generation Rates (tons/year) Average/ Plant	Other Relevant Ranking Factors	Research Priorities
Aqueous spent antimony waste from fluoromethane production	K021	Carbon tetrachloride	8000 ppm	+2	II	13	120-240 kkg	9.2-18.4 kkg		Low
		Chloroform	8000 ppm	+2						
		Antimony	.000117 kg/kg product							
Ammonia still lime sludge from coking operations	K060	Cyanide	14,000 ppm		I	39	1500 tons (dry)	39 tons	Land area required to assimiliative arsenic is modest. Cyanides are degraded by biological reactions in soils, but are also highly soluble. Application rates must be balanced so that the rate of biodegradation exceeds the rate of leaching of unacceptably high cyanide concentrations to receiving waters	High
		Napthalene	4,770 ppm	+4						
		Phenolic Compounds	680 ppm	+4						
		Arsenic	1,086 ppm							

*For information on waste streams excluding persistence:

"Background Document - Resource Conservation and Recovery Act, Subtitle C - Identification and Listing of Hazardous Waste," U.S. Environmental Protection Agency, Office of Solid Waste, unpublished report dated May 2, 1980.

For information on persistence, the source is Arthur D. Little, Inc.

TABLE 10. RESULTS OF APPLYING THE CYANIDE SCREEN*

Waste Streams	ID No.	Heavy Metals	Metal Conc. (kg/kkg)	No. of Plants	Waste Stream Generation Rates (kg)	
					Total Annual	Average Annual
Spent cyanide plating bath solutions from electroplating operations (except for precious metals electroplating spent cyanide plating bath solutions)	F007	Cyanide salts Heavy metals unspecified	40-350,000 ppm	10,000	42,000 kkg (F007, F008, F009 tog.)	4.2 kkg
Plating bath sludges from the bottom of plating baths from electroplating operations where cyanides are used in the process (except for precious metals electroplating plating bath sludges)	F008	Cyanide salts Heavy metals unspecified	40-350,000 ppm	10,000	42,000 kkg (F007, F008, F009 tog.)	4.2 kkg
Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process (except for precious metals electroplating spent stripping and cleaning bath solutions	F009	Cyanide salts Heavy metals unspecified	40-350,000 ppm	10,000	42,000 kkg	4.2 kkg
Quenching bath sludge from metal heat treating operations where cyanides are used in the process (except for precious metals heat-treating quenching bath sludges)	F010	Cyanide salts Heavy metals unspecified	8,500-92,000 ppm	7000	6,000 kkg (F010, F011, F012 tog.)	--
Spent cyanide solutions from salt bath pot cleaning from metal heat treating operations (except for precious metals heat treating spent cyanide solutions from salt bath pot cleaning)	F011	Cyanide salts Heavy metals unspecified	92,300 ppm	7000	6,000 kkg	

(continued)

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TABLE 10 (continued)

Waste Streams	ID No.	Heavy Metals	Metal Conc. (kg/kkg)	No. of Plants	Waste Stream Generation Rates (kg)	
					Total Annual	Average Annual
Quenching wastewater treatment sludges from metal heat treating operations where cyanides are used in the process (except for precious metals heat treating quenching wastewater treatment sludges)	F012	Cyanide (complexed) Heavy metals unspecified	8,400-92,300	7000	6,000 kkg (F010, F011, F012 tog.)	--
Flotation tailings from selective flotation from mineral metals recovery operations	F013	Cyanide (complexed) Heavy metals unspecified	1000 ppm	73	1,000 kkg (F013, F014, F015 tog)	--
Cyanidation wastewater treatment tailing pond sediment from mineral metals recovery operations	F014	Cyanide (complexed) Heavy metals unspecified	1000 ppm	73	1,000 kkg (F013, F014, F015 tog.)	
Spent cyanide bath solutions from mineral metals recovery operations	F015	Cyanide (complexed) Heavy metals unspecified	1000 ppm	73	1,000 kkg (F013, F014, F015 tog.)	

*For information on waste streams excluding persistence:

"Background Document - Resource Conservation and Recovery Act, Subtitle C - Identification and Listing of Hazardous Waste," U.S. Environmental Protection Agency, Office of Solid Waste, unpublished report dated May 2, 1980.

For information on persistence, the source is Arthur D. Little, Inc.

SECTION 4

DISCUSSION

LIMITATIONS OF THE SCREENING METHODOLOGY

The screening results presented in Section 3 provide only a relative ranking of listed hazardous waste streams in terms of their suitability for land treatment. Waste streams assigned a low potential in Tables 5 through 8 are not necessarily unsuitable for land treatment. Rather, they appear to be less suitable than waste streams assigned a high potential, based on available data.

Data available on listed hazardous waste streams focus primarily on hazardous constituents, and often on only a subset of the hazardous constituents that justify the listing. In practice, of course, the entire waste stream, not merely the hazardous constituents or the subset of hazardous constituents that justify listing, would be incorporated into the soil at a land treatment facility.

The technical feasibility of land treatment can be strongly influenced both by trace quantities of hazardous constituents not cited as a basis for listing, and by constituents that are not normally considered hazardous. As an example of the first factor, several petroleum refining industry wastes are listed because they contain lead and chromium. The background documents do not indicate that some of these waste streams may contain small quantities of highly persistent polynuclear aromatic hydrocarbons. These could be the critical constituents limiting the rate of waste application and the total quantity of waste to be applied at a particular land treatment site. As an example of the second factor, the presence of salt (not normally considered hazardous) needs to be taken into account in assessing the technical feasibility of land treatment and in designing a suitable land treatment facility.

For the screening purposes of this report, the potential treatability of hazardous components cited as a basis for listing is appropriate. For assessing the suitability of land treatment for a given waste stream from a particular plant, all constituents of the waste stream need to be known.

For screening purposes, general information on assimilative capacity can be used effectively. For assessment purposes, direct laboratory and field measurements of assimilation must be made for the specific waste stream being studied under the specific conditions of the land treatment site under consideration.

RECOMMENDATIONS FOR IMPROVING THE SCREENING

Listed hazardous waste streams that appear to be primary candidates for land treatment are displayed in Table 6. Available information on generators of the high priority waste streams in Table 6 is summarized in Table 11. This section provides recommendations for applied research to further develop the screening procedure.

The second step of an applied research program would be to obtain specific documented data on the waste stream, including:

- quantity and frequency of waste stream generation;
- major organic and inorganic constituents of the waste stream, including water, to account for close of 100% of the total sample weight; and
- trace organic and inorganic constituents of the waste stream.

Data that would typically need to be developed include:

- Mechanisms of degradation of the constituents of the waste under the prevailing conditions at the selected site(s) (e.g., rates and products of degradation as a function of soil loading, pretreatment, fertilizer addition, etc.).
- Mobility of constituents of the applied wastes and of the degradation products (each chemical compound can migrate out of or through the soil environment in two basic soil-to-air transport through volatilization and soil-to-water transport through run-off or leaching).

  Mobility in air will be influenced by the inherent volatility of the chemical and also by its tendency to adsorb or bind to soil. A useful index of mobility in air is the ratio of the vapor pressure at 25°C to the octanol-water partition coefficient as an indication of probable soil binding tendency[9] for each chemical compound. These data are presented in Table 12 for known hazardous waste stream constituents. The octanol-water partition coefficient (K_{ow}) was used instead of the soil sorption coefficient (K_{oc}) because the former is more readily available. A known relationship exists between K_{ow} and K_{oc} (Karickoff, et. al 1979[11]).

$$\log K_{oc} = 1.377 + 0.544 (\log k_{ow})$$

  The octanol-water partition coefficient has been used as an estimate of soil affinity in previous publications (see, for example, Kenaga and Goring [9]).

TABLE 11. GENERATORS OF CANDIDATE WASTE STREAMS FOR LAND TREATMENT RESEARCH

EPA waste stream no.*	Known generators
K009	Celanese Chemical, Bay City, TX Celanese Chemical, Clear Lake City, TX Texas Eastman, Longview, TX
K010	Celanese Chemical, Bay City, TX Celanese Chemical, Clear Lake City, TX Texas Eastman, Longview, TX
K013	American Cyanamid, New Orleans, LA Dupont, Memphis, TN Monsanto, Chocolate Bayou, TX Monsanto, Texas City, TX Standard Oil, Lima, OH
K014	American Cyanamid, New Orleans, LA Dupont, Memphis, TN Monsanto, Chocolate Bayou, TX Monsanto, Texas City, TX Standard Oil, Lima, OH
K093	Allied Chemical Corp., El Segundo, CA BASF Wyandotte Corp., S. Kearny, NJ Chevron Chemical Co., Richmond, CA Exxon Chemical Co., Baton Rouge, LA Koppers Co., Inc., Chicago, IL Monsanto Co., Texas City, TX Puerto Rico Chemical Co., Arecibo, PR Stepan Chemical Co., Millsdale, IL
K026	
K036	Kansas City, MO (one plant)
K037	Kansas City, MO (one plant)

* See Table 6 for waste stream description.

Mobility in water depends upon solubility and the affinity of the chemical for water as compated with soil. Solubility data and octanol-water partition coefficients for hazardous waste constituents are included for reference in Table 12.

- Toxicity indices for hazardous components of listed waste streams and degradation products that could be released from the land treatment site are compiled for reference in Table 13.

The threshold limit value (TLV) concentration in air is that concentration considered acceptable for occupational exposures over an 8-hr day, 40-hour week. The VHI (vapor hazard index) is a measure of potential hazards associated with volatile materials. This figure is determined as the ratio between vapor concentrations 500 yards downwind from a part of the chemical and the TLV or LC_{50} concentration for that compound. When the TLV is used, a VHI $\geq$10 to 100 is necessary to indicate a highly probable threat, since the TLV has a margin of error. When the LC_{50} is employed, a VHI $\geq$1 to 10 indicates a high potential for vapor threat. The chronic water hazard index (CWHI) was devised to provide an insight into potential chronic exposure problems. This index is defined as:

$$CWHI = \frac{\text{Solubility (mg/L)}}{\text{MAC (mg/L)}}$$

where MAC is the human health criteria level set for priority pollutants (and thus is available only for the priority pollutants). A value greater than one means that a potential exists for a compound to present a chronic toxic hazard. The drinking water hazard index (DWHI) is a measure of relative acute hazard. This figure is defined as the ratio of the water solubility to the lethal concentration of a compound in water consumed in a 24-hr. period. The lethal concentration assumes that a 70-kg man consumes 2L of water a day and is defined as the concentration at which a body burden equivalent to that received with an LD_{50} is obtained. Therefore:

$$DWHI = \frac{\text{Solubility (mg/L)}}{35 \times LD_{50}\ \text{(mg/L)}}$$

When the DWHI index is greater than one, the compound is soluble enough to produce lethal levels in water.

TABLE 12. PHYSICAL CONSTANTS

Organic Compound	H_2O Solubility[1]	Volatility[1]	K_{ow} (10^x)	$\frac{VP \text{ @ } RT}{K_{ow}}$
Acetonitrile	Miscible	1.3 psia @ 20°C (too soluble)	$10^{-0.34}$	144
Acrolein	400,000 ppm @ 25°C	210 mm Hg @ 20°C	10^{0}	210
Acrylamide	215.5 g/100 ml.	.007 mm Hg @ 25°C	$10^{-.999}$	5.8×10^{-2}
Acrylonitrile	7.35 g/100 g @ 20°C	80 mm Hg @ 20°C	$10^{-0.92}$	665
Benzal chloride	Insoluble	0.2 mm Hg @ 22°C	$\sim 10^{4}$	
Benzanthracene	0.011 mg/L		$10^{5.63}$	
Benzene		95 400 mm @ 28°C	135	0.7
Benzofluoranthrene	0.01 mg/L		10^{6}	
Benzopyrene	0.012 mg/L		$10^{6.04}$	
Benzotrichloride	Insoluble	0.22 mm @ 22°C	$10^{4.03}$	2.05×10^{-5}
Benzyl chloride	0.33 g/100 g @ 25°C	1 mm Hg @ 22°C	$10^{2.63}$	2.3×10^{-3}
Carbon disulfide		662 400 mm @ 28°C	-331	-2
Carbon tetrachloride	800 mg/L @ 20°C	91 mm Hg @ 20°C t1/2 = 28 min	$10^{2.64}$	2.1×10^{-1}
Chlordane	9 ppb @ 25°C	1×10^{-5} mm Hg @ 25°C	$10^{4.6}$	2.5×10^{-10}
Chlorinated flurocarbons				
Chloroacetaldehyde	10,000 ppm	100 mm Hg @ 45°C	$10^{0.3}$	50
Chlorobenzene	488 mg/L @ 25°C	10 mm Hg @ 22°C	$10^{2.84}$	1.45×10^{-2}
Chloroethers	Insoluble	0.80 mm Hg @ 20°C	10^{0}	0.8
Chloroform	8,200 ppm @ 25°C	160 mm @ 20°C t1/2 = 23.4 min	10^{2}	1.6
Chrysene		4.1×10^{-9} 400 mm @ 28°C	4.1×10^{5}	10^{-14}
Creosote	Insoluble 5000 g/L		10^{0}	
Cresylic acid (see phenol)				
Dichloroethane	8,700 ppm	60 mm Hg @ 20°C	$10^{1.5}$	1.9
o-Dichlorobenzene	123 mg/L @ 25°C	1 mm @ 20°C	$10^{3.4}$	3.9×10^{-4}
2,4-Dichlorophenol	4,600 ppm @ 20°C	0.22 mm @ 22°C	$10^{3.14}$	1.59×10^{-4}
2,6-Dichlorophenol	0.279 mg/L	~0.25 mm @ 25°C	$10^{2.9}$	3.1×10^{-4}

continued

TABLE 12. (continued)

Organic Compound	H_2O Solubility[1]	Volatility[1]	K_{ow} (10^x)	$\frac{VP\ @\ RT}{K_{ow}}$
Dichloropropanol	Slightly to very	0.8 mm Hg @ 20°C	$\sim 10^0$	
Dimethyl phenol			631	
m-Dinitrobenzene	~20 ppm	~.5 mm Hg @ 20°C	$10^{1.62}$	6×10^{-3}
4,6-Dinitro-o-cresol			501	
2,4-Dinitrotoluene	Insoluble	$\leq$1 mm Hg @ 22°C	10^2	
Epichlorohydrin	66,000 ppm @ 25°C	20 mm Hg @ 29°C	10^0	20
Ethylchloride	4,500 ppm @ 25°C	1.33 atm @ 20°C	$10^{1.43}$	37
Ethyldichloride (1,2-)				
Formaldehyde	Miscible	0.027 psia @ 20°C	10^0	1.46
Formic Acid	Miscible	0.62 psia @ 20°C	$10^{-0.54}$	109
Heptachlor	0.056 mg/L @ 25°C	3×10^{-4} mm Hg @ 25°C	$10^{3.9}$	3.75×10^{-8}
Hexachlorobenzene	0.035 ppm	1.089×10^{-5} mm Hg @ 20°C	$10^{4.2}$	6.9×10^{-10}
Hexachlorobutadiene	5 µg/L @ 20°C	0.15 mm Hg	$10^{4.6}$	3.7×10^{-6}
Hexachlorocyclopentadiene	27.3 ppm	.08 mm Hg @ 25°C	$10^{3.99}$	8.16×10^{-4}
Hexachloroethane	50 ppm Insoluble	0.47 mm @ 22°C	$10^{1.25}$	2.6×10^{-2}
Hydrocyanic acid	1×10^6 ppm @ 25°C	658.7 torr @ 21.9°C	$10^{-0.25}$	1170
Isobutyl alcohol				
Maleic anhydride	163,000 ppm @ 30°C	0.27 mm @ 22°C	$10^{-.58}$	1.03
Methanol		100 @ 21°C	$10^{-.75}$	562
Methylchloride	400 ppm @ 25°C	760 mm Hg @ -24°C	$10^{0.91}$	>>95
Methylene chloride	20,000 mg/L @ 25°C	350 mm Hg @ 20°C	$10^{1.3}$	17.54
Methyl ethyl ketone		100 @ 25°C	$10^{.35}$	45
Methyl isobutyl ketone				
Napthaquinones	200 mg/L ? ß more sol.	~0.22 mm @ 22°C	$10^{1.74}$	3.96×10^{-3}
Naphthalene		0.10	1950	5×10^{-5}
Nitrobenzene	1,900 ppm @ 25°C	0.25 mm @ 22°C	$10^{1.79}$	1.6×10^{-2}
Nitrophenol (2-)		0.17	56	0.003
Paraldehyde	120,000 ppm @ 18°C	25.3 mm Hg @ 20°C	$10^{1.15}$	1.79

continued

TABLE 12. (continued)

Organic Compound	H_2O Solubility(1)	Volatility(1)	K_{ow} (10^x)	VP @ RT / K_{ow}
Phenol	67,000 ppm @ 25°C	0.35 mm Hg @ 25°C	$10^{1.5}$	1.1×10^{-2}
Phorate	50 ppm	8.4×10^{-4} mm Hg @ 20°C	$10^{1.25}$	4.7×10^{-5}
Phosphorodithioic acid	100 ppm		10^{0}	
Phosphorodithioic esters	100 ppm		10^{0}	
Phosphorothioic esters	1000 ppm		10^{0}	
Picoline	Miscible	∿15 mm Hg @ 22°C	10^{1}	
Pthalic anhydride	6,200 ppm	2×10^{-4} torr @ 20°C	$10^{-.62}$	8.32×10^{-4}
Pyridine	Miscible	20 mm Hg @ 20°C	$10^{0.66}$	4.4
Quinones	Soluble	<1 mm Hg @ 22°C	10^{1}	
Tars (PAHs)	see Benzanthracene)			
Tetrachloroethane 1,1,1,2- 1,1,2,2-	4,500 ppm	5.0 mm Hg @ 20°C	$10^{2.6}$	1.25×10^{-2}
Tetrachloroethylene	Insoluble	∿20 mm Hg @ 22°C		
Tetrachlorophenol		1.0	$10^{4.1}$	8×10^{-5}
Toluene	470 ppm @ 25°C	28.9 mm Hg @ 25°C	$10^{2.07}$	0.24
Toluene diamines	Slightly to very	∿.2 mm Hg @ 22°C		
Toluene diisocyanates	Reacts			
Toxaphene	3 ppm @ 25°C	0.4 mm Hg @ 25°C	$10^{2.9}$	5×10^{-4}
Trichloroethane	950 ppm	100 mm Hg @ 20°C	$10^{2.2}$	0.63
Trichloroethylene	Insoluble	70 mm Hg @ 22°C	$\sim 10^{2}$	
o,o,o-Triethyl ester, phosphorodithioic acid	1,000 ppm		10^{0}	
2,4,6-Trichlorophenol	800 ppm @ 25°C	∿0.028 mm @ 22°C	$10^{3.62}$	6.7×10^{-6}
Trichloropropane	<1.000 ppm	2 mm Hg @ 20°C	10^{0}	2
Vinyl chloride	Slightly	>1 atm @ 22°C		
Vinylidene chloride	Insoluble	∿500 mm Hg @ 22°C		

(1) Handbook of Chemistry and Physics; Appendix B4 - The Background Documents for Listing of Hazardous Wastes

(2) Lev, et. al. (1971)

TABLE 13. TOXICITY DATA FOR HAZARDOUS COMPONENTS OF LISTED WASTE STREAMS

Organic Compound	TLV*	VHI†	CWHI‡	DWHI**	Rat LD_{50}
Acetonitrile	40 ppm	487 (TLV)		0.752	3800 mg/Kg
Acrolein	0.1 mg/m^3	6.63×10^5 (TLV)	6.2×10^7	248	46 mg/Kg
Acrylamide	0.1 ppm	18.4 (TLV)		410	150 mg/Kg
Acrylonitrile	20 ppm	1050 (TLV)	8.8×10^8	226	93 mg/Kg
Benzal chloride	~1 ppm				
Benzanthracene	0.01 ppm				10 mg/Kg
Benzofluoranthrene	0.01 ppm				72 mg/Kg TD_{LO} (isomer)
					288 mg/Kg TD_{LO} (isomer)
Benzopyrene	0.01 ppm				50 mg/Kg
Benzotrichloride	~1 ppm	1.05 (LD_{LO})			125 ppm over 4 hrs.
Benzyl chloride	1 ppm	263 (TLV)			
Carbon tetrachloride	LC_{50} = 7 hr. 7800 ppm	3.07 (LC_{50})	3×10^5	5.71×10^{-3}	4000 mg/Kg
Chlordane	0.5 mg/m^3	6.31×10^{-3} (TLV)	9.5	5.14×10^{-4}	500 mg/Kg
Chloroacetaldehyde	1 ppm	1.32×10^4		497	23 mg/Kg (Oral)
Chlorobenzene	75 ppm	35.1 (TLV)	2.4×10^4	4.79×10^{-3}	2910 mg/Kg
Chloroethers	1-15 ppb	12.4 (BCEE)(TLV)	2.4×10^{10}	3.99 (BCEE)	
Chloroform	25 ppm	1680 (TLV)	3.9×10^6	0.125	1875 mg/Kg
Creosote					
Dichloroethane	50 ppm	72 (TLV)	1.2×10^6	.323	7 µg/L
o-Dichlorobenzene	821 ppm for 7 hrs.	0.700	5.4×10^2	7.03×10^{-3}	Human 500 mg/Kg
2,4-Dichlorophenol			9.2×10^6	.306	430 mg/Kg
2,6-Dichlorophenol			93	0.337	390 mg/Kg
Dichloropropanol					

* Threshold limit value
† Vapor hazard index
‡ Chronic water hazard index
** Drinking water hazard index

continued

TABLE 13. (Continued)

Organic Compound	TLV*	VHI	CWHI	DWHI**	Rat LD_{50}
m-Dinitrobenzene	1 ppm				Dog LD_{50} = 750 mg/Kg
2,4-Dinitrotoluene	<1 ppm				268 mg/Kg
Epichlorohydrin	5 ppm	67.0 (TLV)		10.5	90 mg/Kg (Oral)
Ethylchloride	1000 ppm	2.66			
Formaldehyde	2 ppm	184		3.6	800 mg/Kg (Oral)
Formic acid	5 ppm	1690		0.71	4000 mg/Kg (Dog oral)
Heptachlor	0.5 mg/m^3	0.19	2.4×10^5	1.23×10^{-5}	130 mg/Kg (Oral)
Hexachlorobenzene	0.08 ppm	3.56×10^{-2} (VHI)	2.8×10^4	2×10^{-5}	50 mg/Kg/d for 30 days
Hexachlorobutadiene	1 ppm	39.4 (TLV)	6.5	3.2×10^{-3}	90 mg/Kg (Oral)
Hexachlorocyclopentadiene	0.01 ppm	2100 (TLV)	2.7×10^4	5.7×10^{-4}	505 mg/Kg
Hexachloroethane	1 ppm	263	8.5×10^3	2.9×10^{-2}	Oral LD_{LO} human = 50 mg/Kg
Hydrocyanic acid	10 ppm	1.44×10^4 (TLV)	2×10^7	52.5	Lethal dose man = .5-1.5 mg/Kg
Maleic anhydride	.25 ppm	1000		5.48	850 mg/Kg (Oral)
Methylchloride	100 ppm	2000	2×10^5		
Methylene chloride	500 ppm	184	10	0.22	2000 mg/Kg (Oral)
Napthaquinones	0.015 ppm			0.015	140 mg/Kg
Nitrobenzene		3.9	6.3×10^4	.072	700 mg/Kg (Oral)
Paraldehyde				2.08	1600 mg/Kg
Phenol	5 ppm	18.4 (TLV)	2×10^4	3.612	530 mg/Kg
Phorate				0.893	1.6-3.7 mg/Kg (Oral)
Phosphorodithioic acid					
Phosphorodithioic esters				0.0266	156 mg/Kg (Oral)
Phosphorothioic esters	220 ppm over 4 hrs, LC_{LO}				
Picoline					800 mg/Kg
Quinones					
Tetrachloroethanes	5 ppm	263 (TLV)	2.5×10^6	0.4	320 mg/Kg

(continued)

TABLE 13. (Continued)

Organic Compounds	TLV*	VHI	CWHI	DWHI**	Rat LD_{50}
Trichloroethanes	350 ppm	75.1 (TLV)	2.8×10^{2}	2.64×10^{-3}	10300 mg/Kg
Trichloroethylene	100 ppm				4900 mg/Kg
o,o,o-Triethyl ester, phosphorodithioic acid	41 ppm, 4 hrs LC_{LO}				
2,4,6-Trichlorophenol				0.028	820 mg/Kg
Trichloropropane	5 ppm	10.5 (TLV)		0.009	320 mg/Kg
Vinyl chloride	200 ppm				25.6 g/Kg
Vinylidene chloride	10 ppm				Dog LD_{50} = 5750 mg/Kg

Finally, the Rat LD_{50} is a measure of the acute oral toxicity hazard, or the quantity of the chemical orally injested required to kill 50% of an exposed rat population over a 24-hr feeding period. Variations such as oral Dog LD_{50}'s are indicated.

A direct correlation has been observed between biodegradability and water solubility. Thus, the least persistent (most readily degraded) water constituents would also generally tend to migrate with leachate or surface run-off. A well-designed land treatment facility will provide for a favorable balance between the rate of degradation and the rate of migration in water.

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